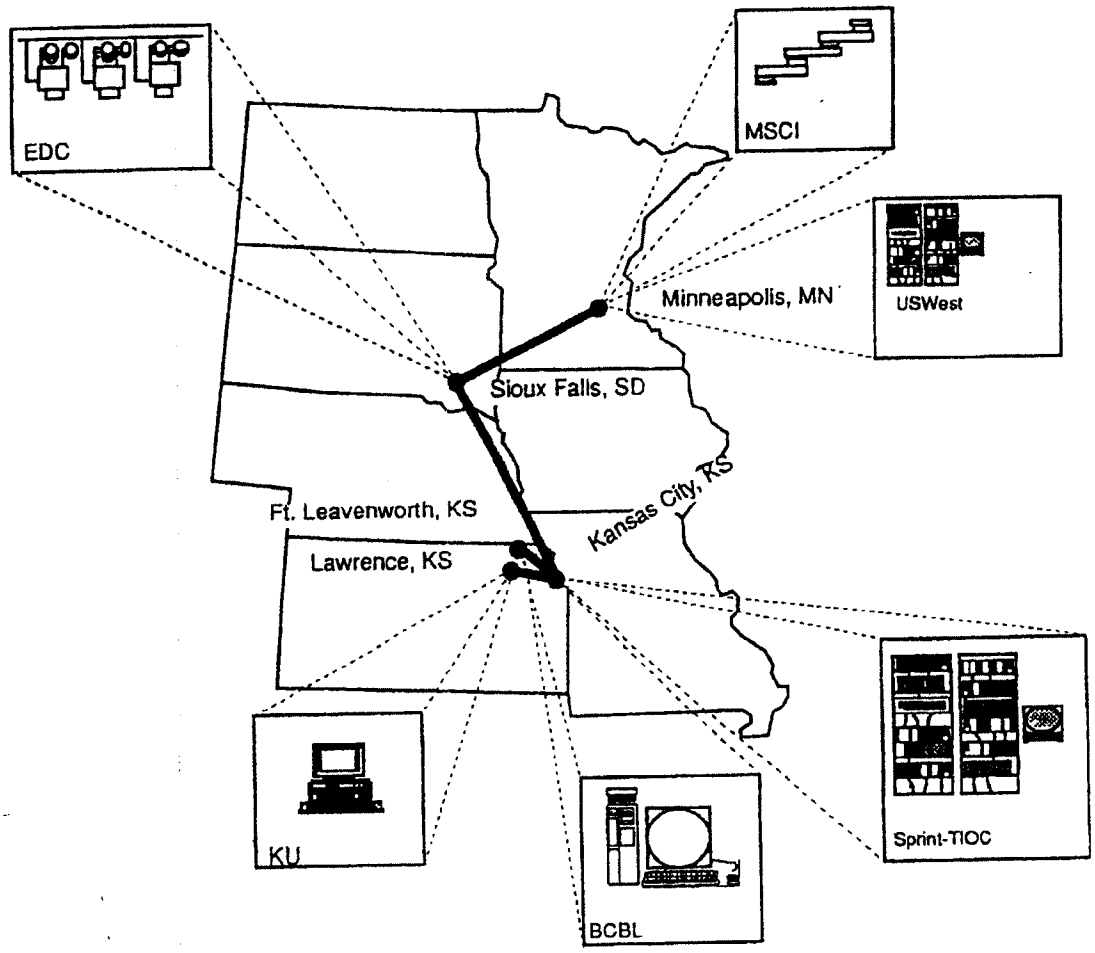
EXHIBIT 33

1995 MAGIC Technical Symposium

August 1-2, 1995
Minneapolis, MN



Part 1: MAGIC Technical Presentations

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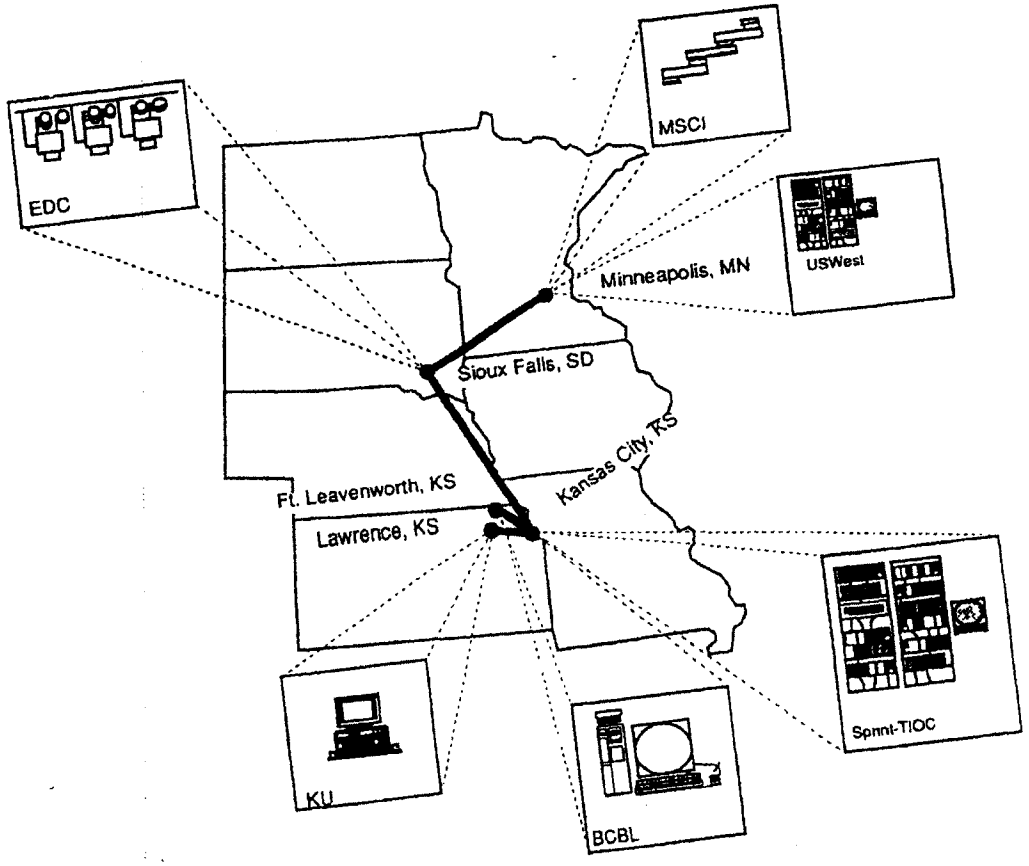

Part 1: MAGIC Technical Presentations

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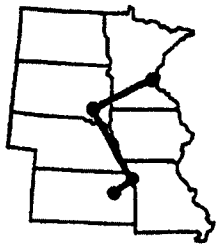

TerraVision Architecture and Performance

Yvan Leclerc
SRI International

TerraVision Architecture and Performance

Yvan G. Leclerc <leclerc@ai.sri.com>
Stephen Q. Lau <lau@ai.sri.com>
Nat Bletter <nat@od.sri.com>
SRI International

1995 MAGIC Technical Symposium - 1 August 1995

Outline

- TerraVision capabilities
- Challenges
- Solution
  - architecture
  - real-time process flow graphs
  - advantages of current approach
- Future work
- Conclusions

TerraVision Capabilities

- TerraVision provides interactive visualization of terrain data with superimposed aerial and satellite imagery
  - images and terrain data are accurately registered to a map
  - current image data set is at 1 meter ground resolution covering about 40 x 30 kilometers of Fort Irwin, or about 1 gigapixel of rectified imagery
  - current terrain data is at 30 meter ground resolution over the same area
- Visualization includes:
  - 2D pan and zoom of images
  - 3D "fly over" or "drive through"
  - superposition of building models and moving vehicles whose positions were acquired via GPS receivers

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Challenges

- Provide high-speed rendering (15 to 30 frames per second) for very large data sets
- Provide real-time visualization with little apparent latency and high image quality given that
  - the rate at which tiles arrive is unpredictable
  - the order in which tiles arrive is unpredictable

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Basic Solution

- Large datasets are rendered at high speed by using a multi-resolution hierarchy of terrain elevation and imagery
  - the amount of data required per frame is roughly constant
  - a high speed quad-tree search algorithm is used to find just the data required for a given frame
  - higher resolution data is used in foreground, lower resolution in background
- Latency is minimized by de-coupling data I/O from graphics
  - required data is requested at regular intervals
  - graphics rendering is done with whatever data is in memory
  - as data arrives, the rendered image quality improves
  - high-speed networks provide high image quality at all times

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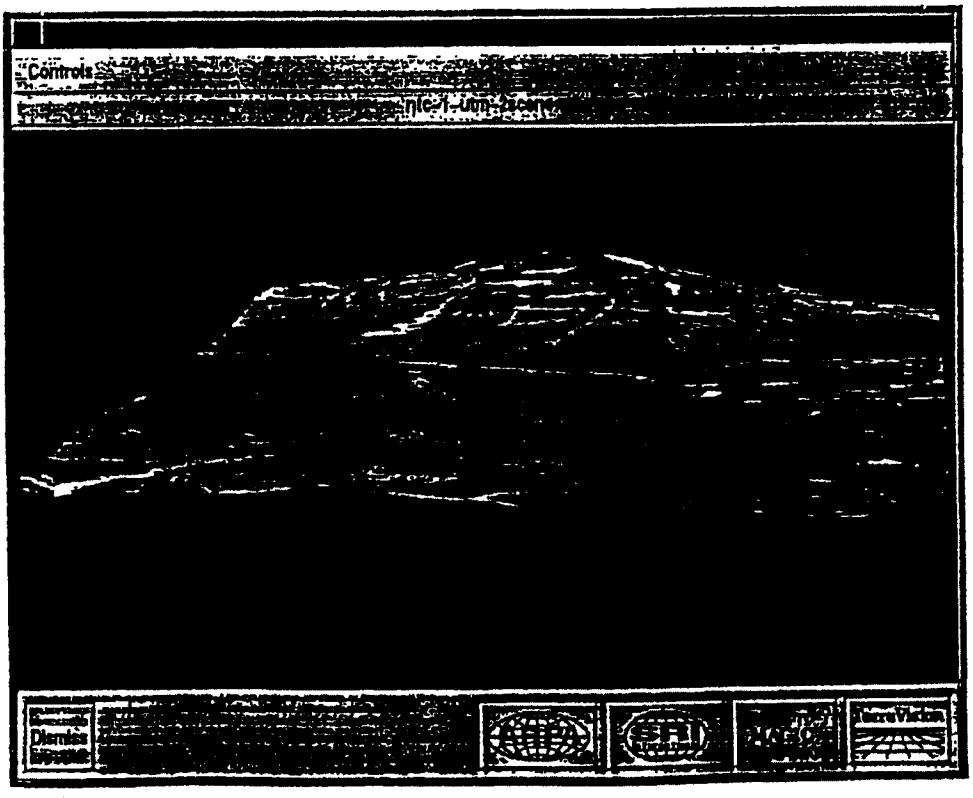

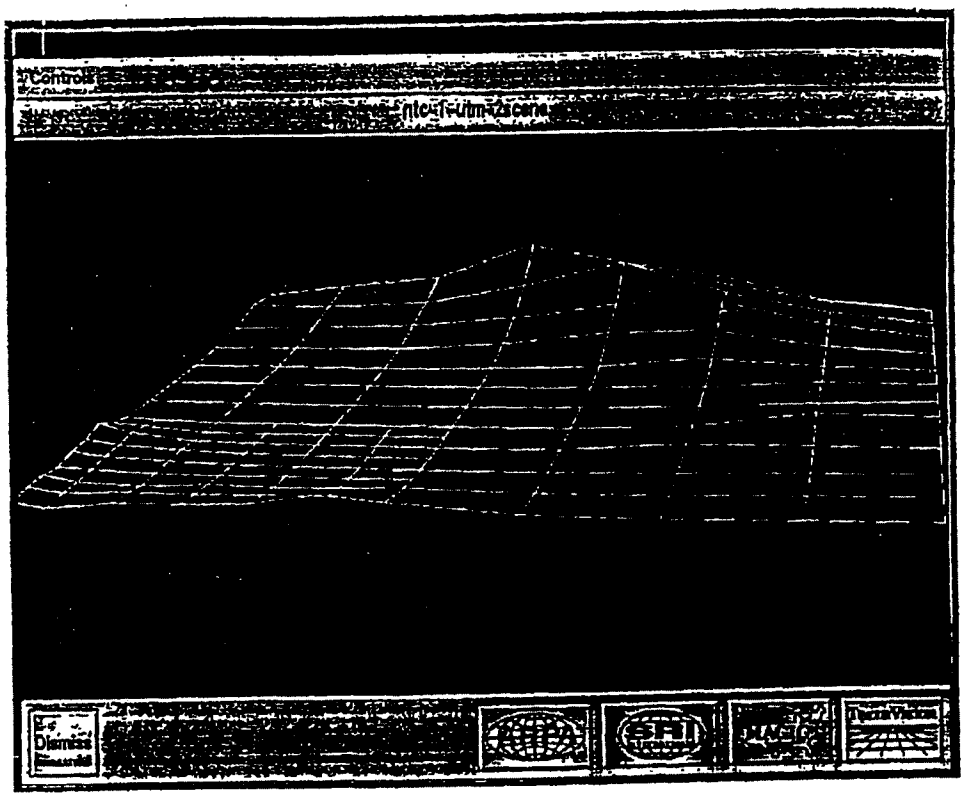

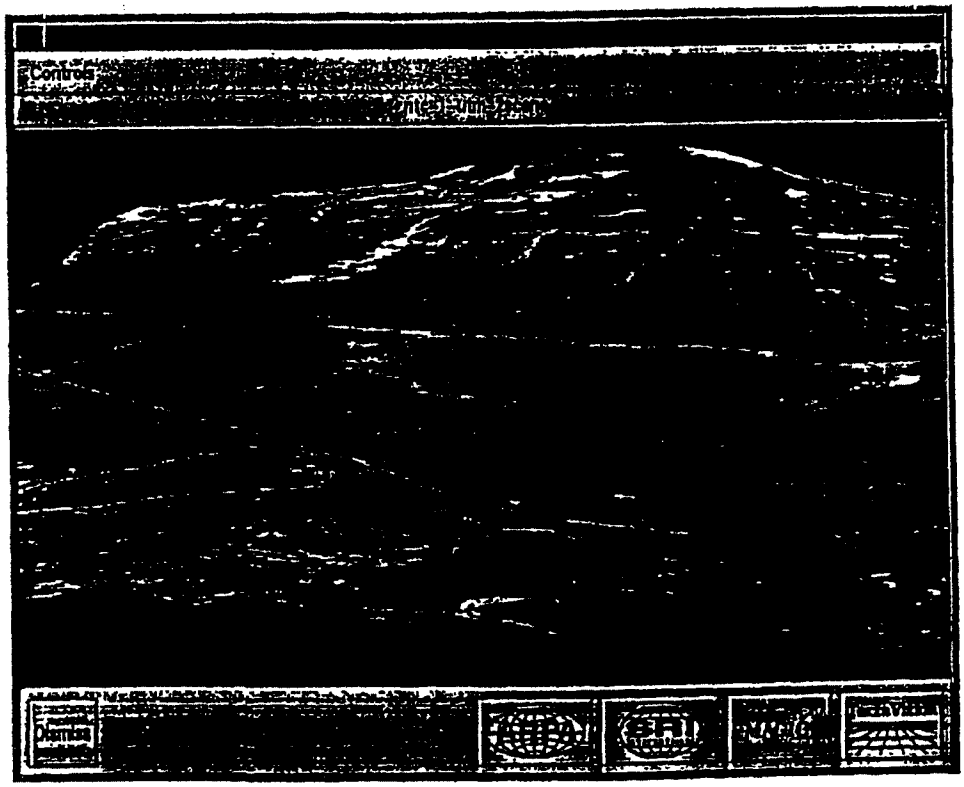


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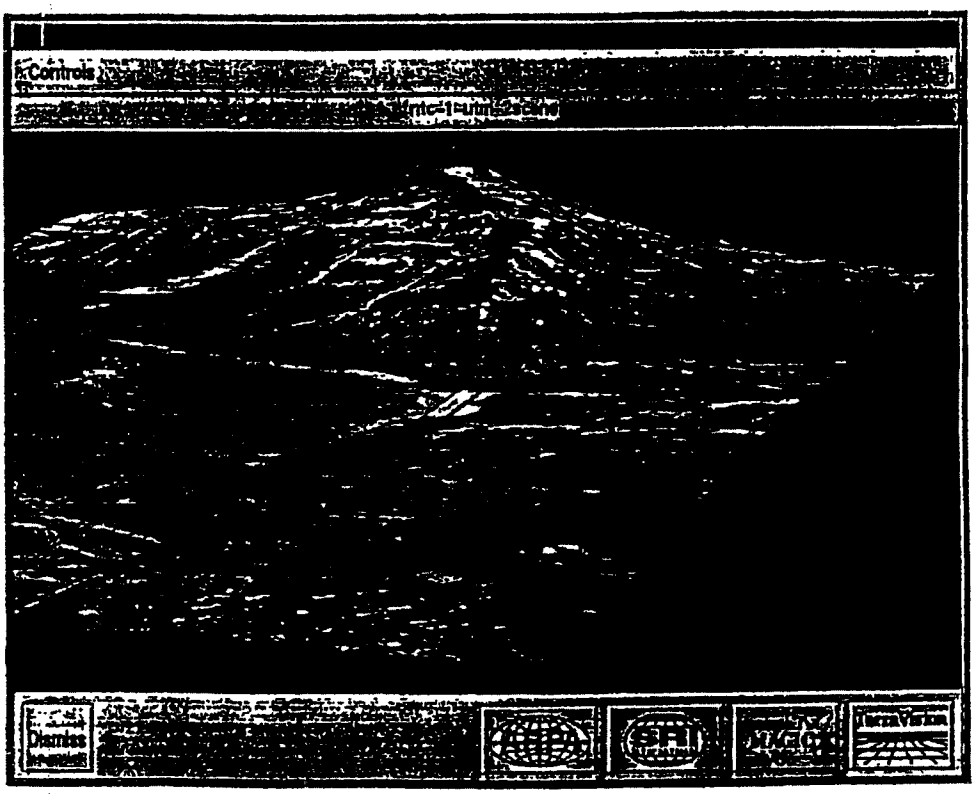
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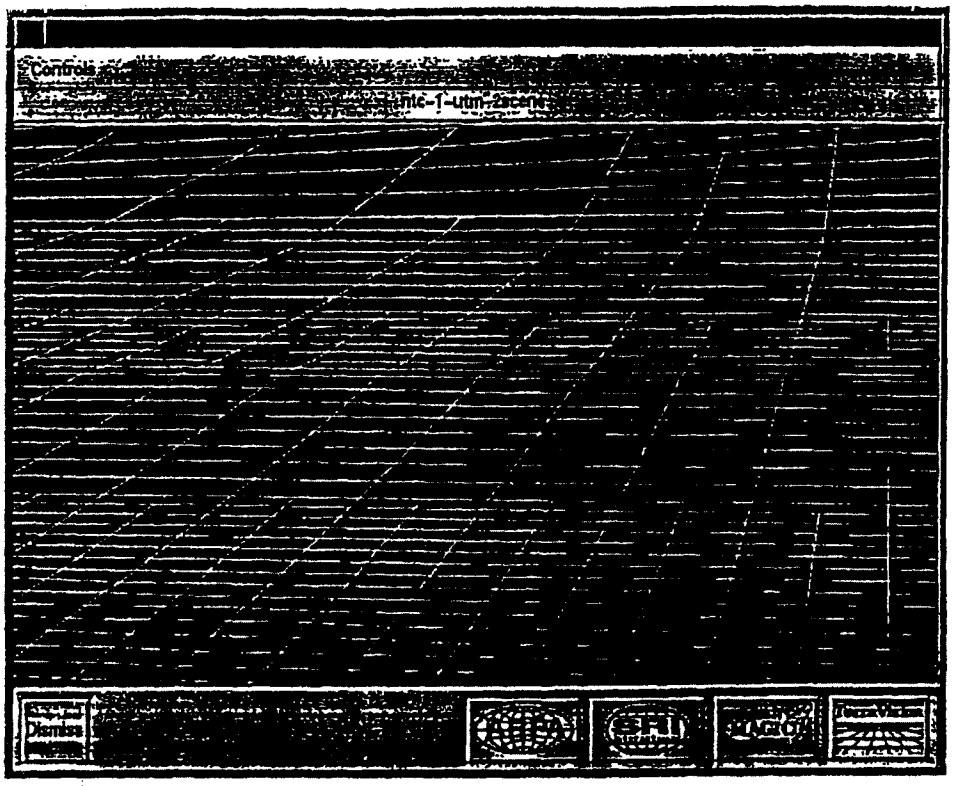
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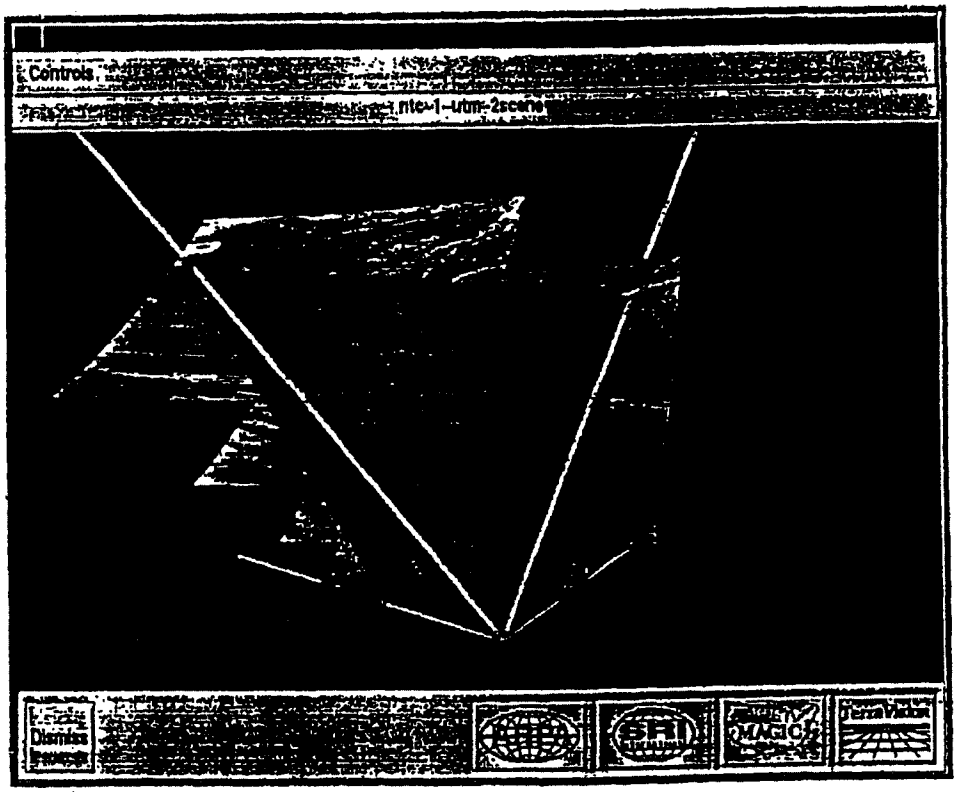
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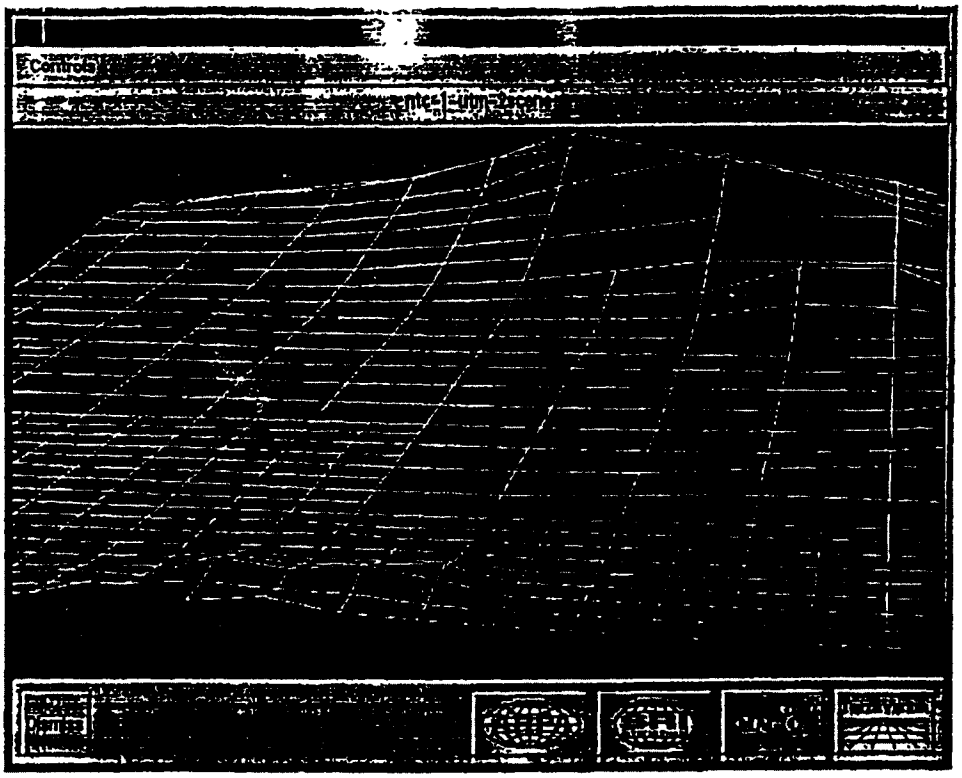
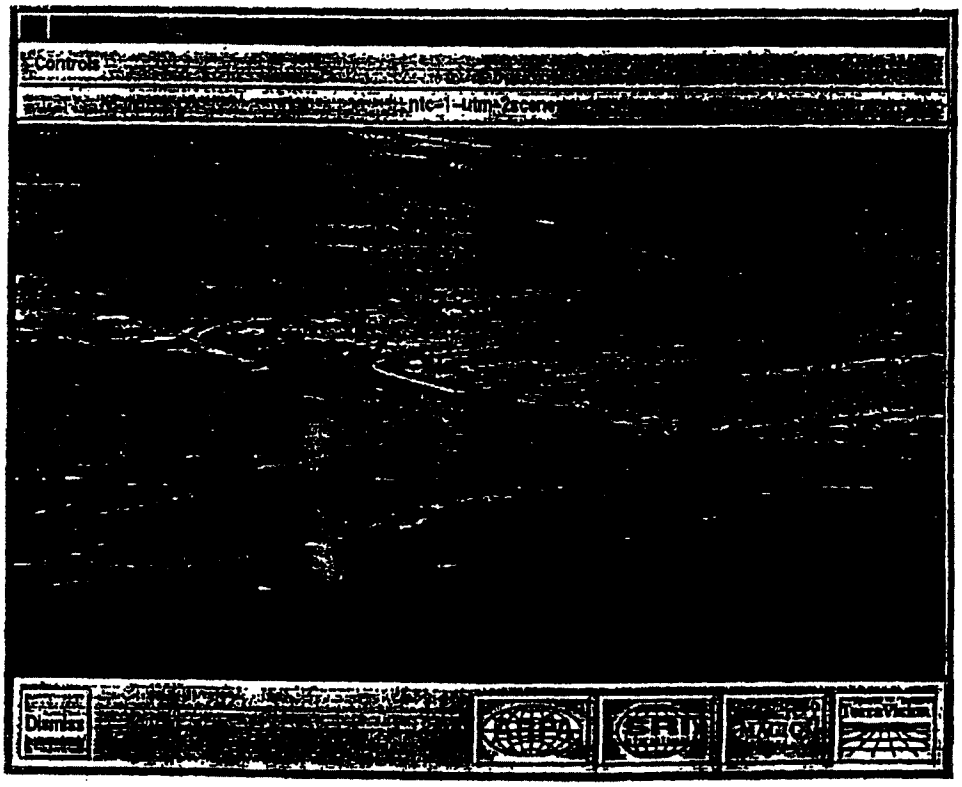
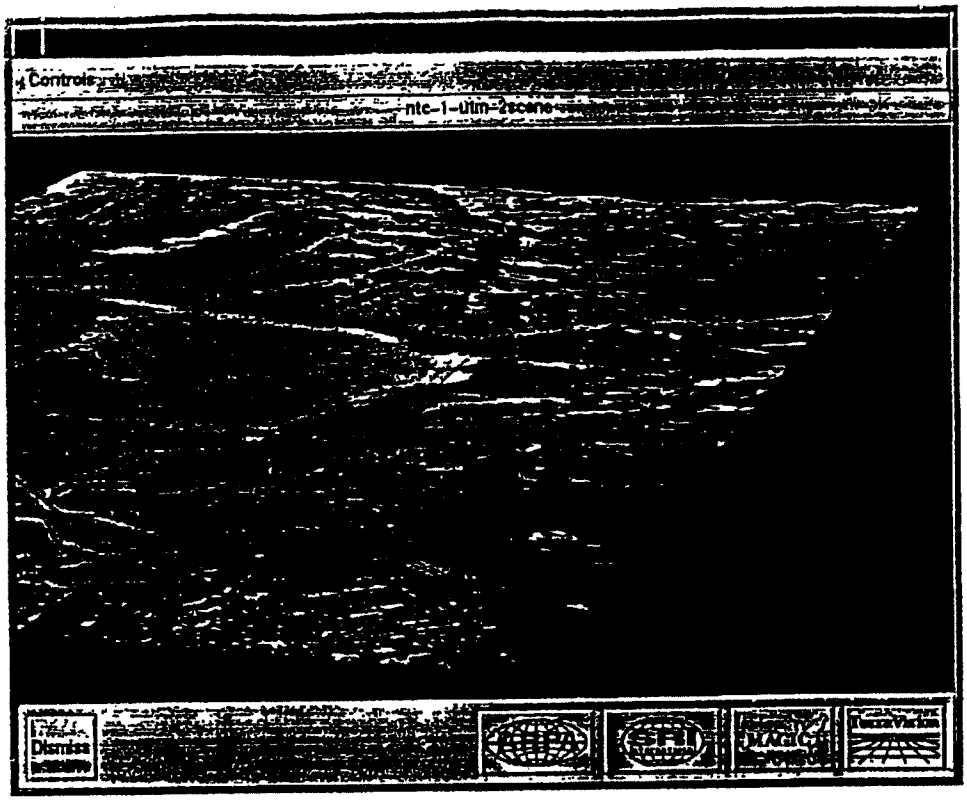
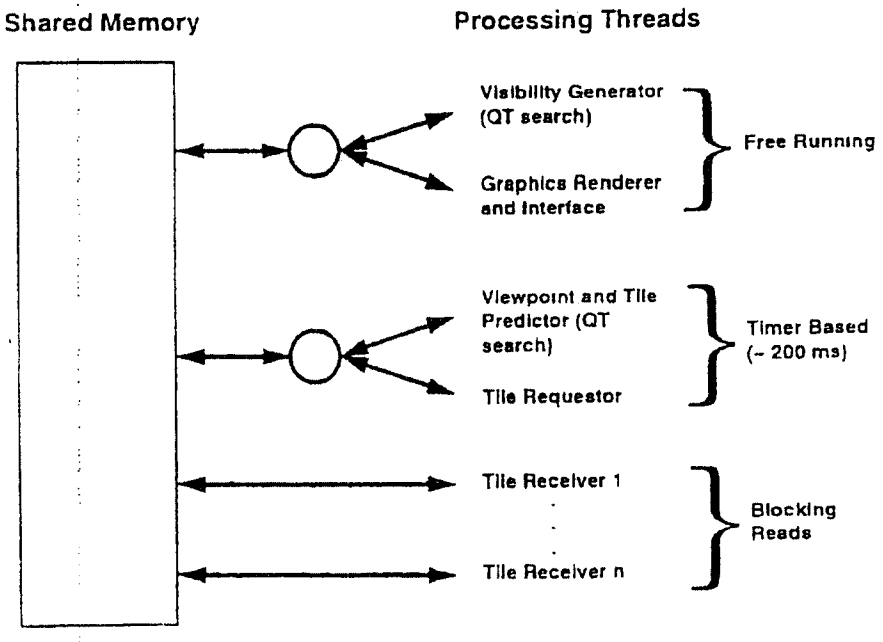






Architecture



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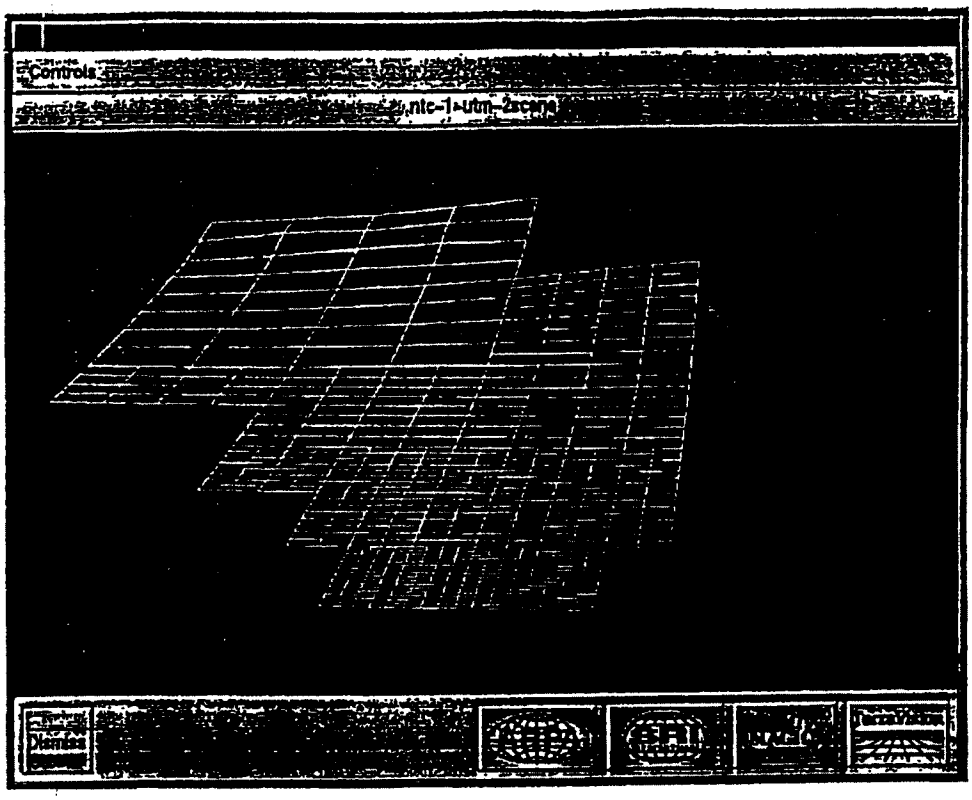
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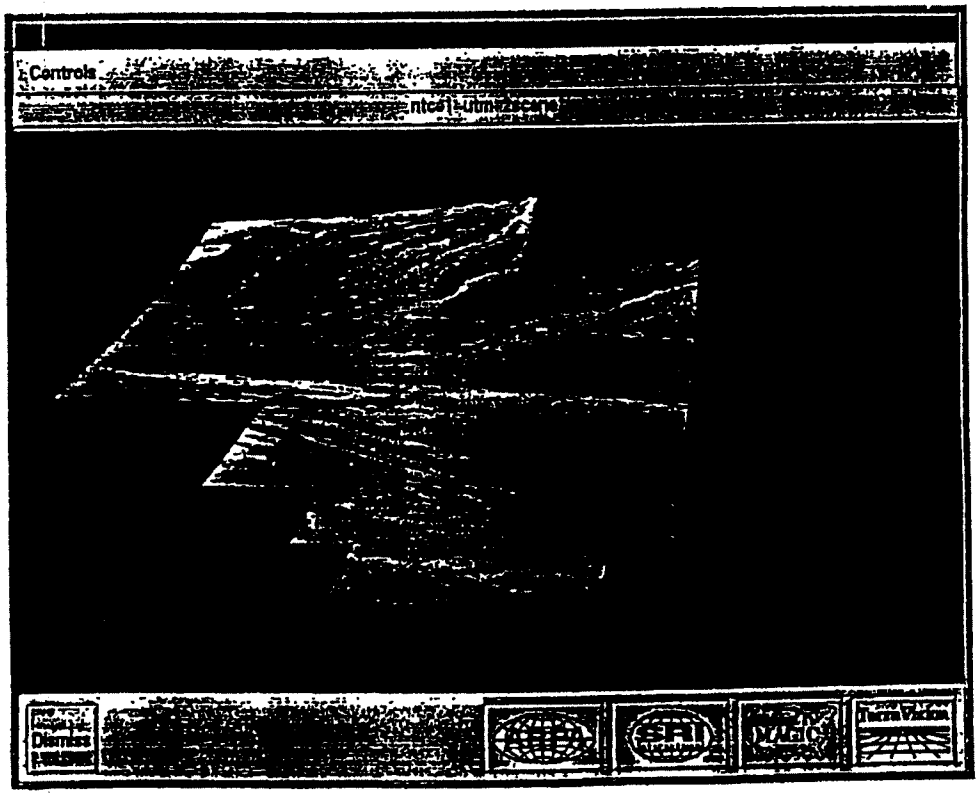
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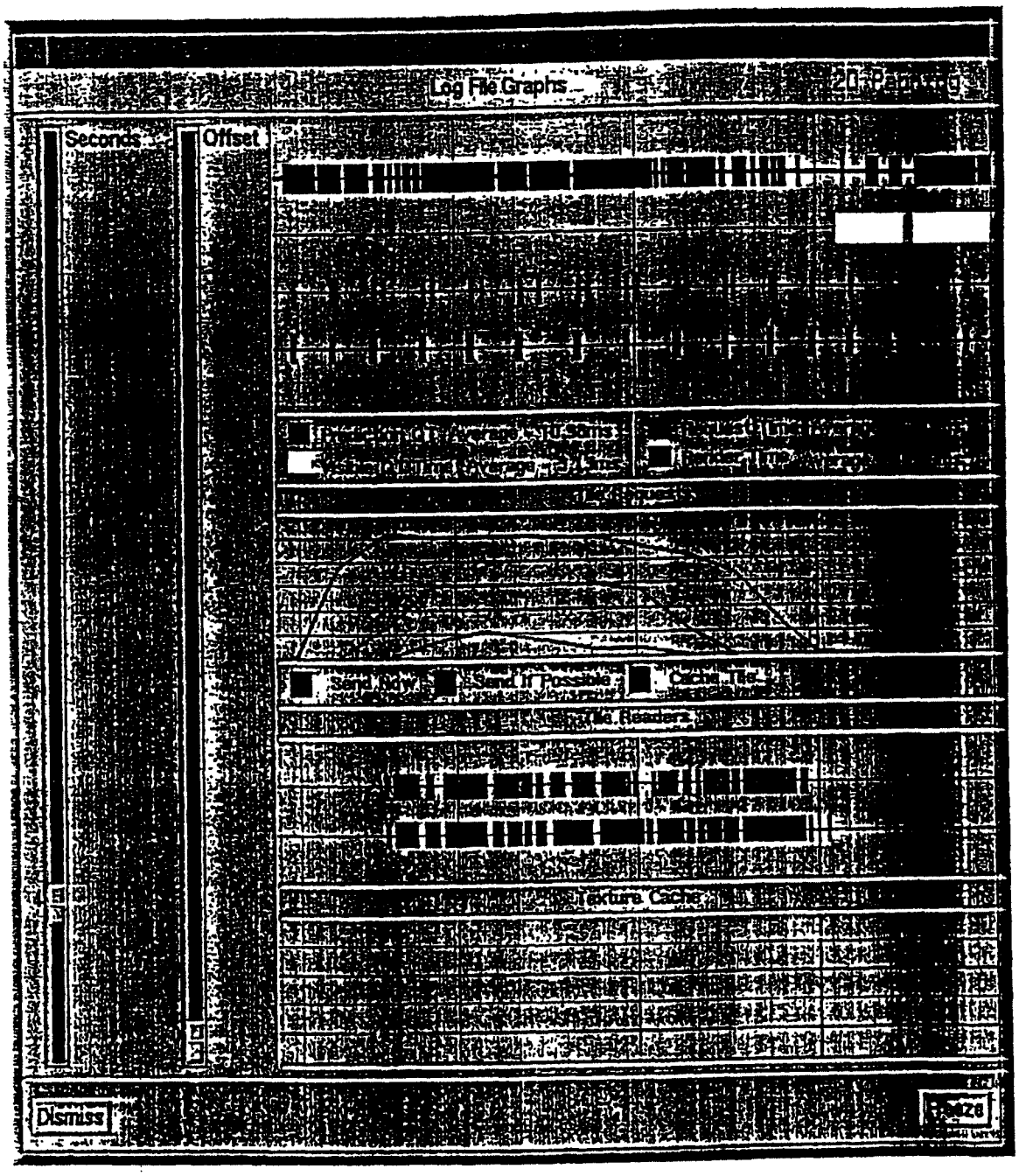
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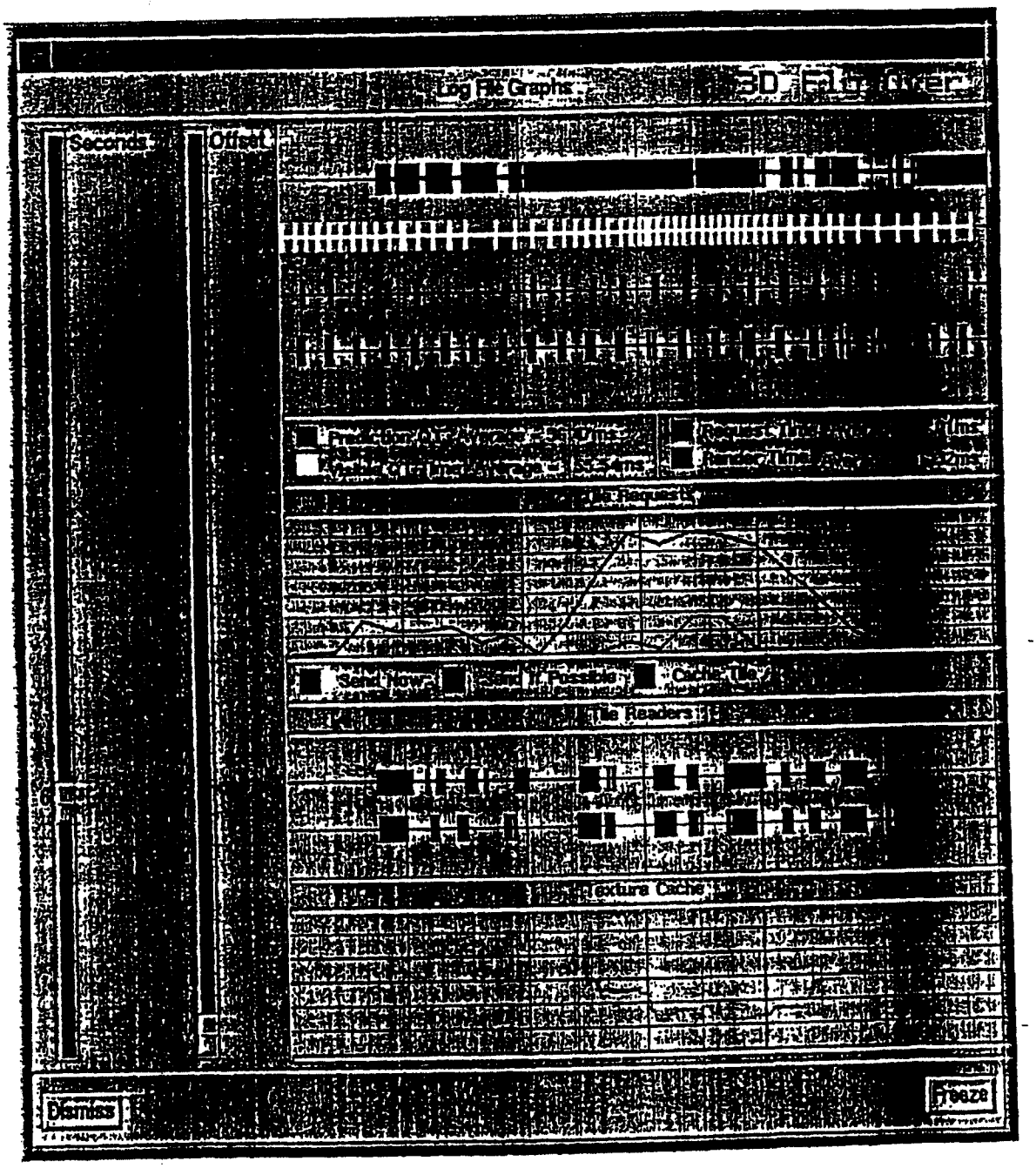
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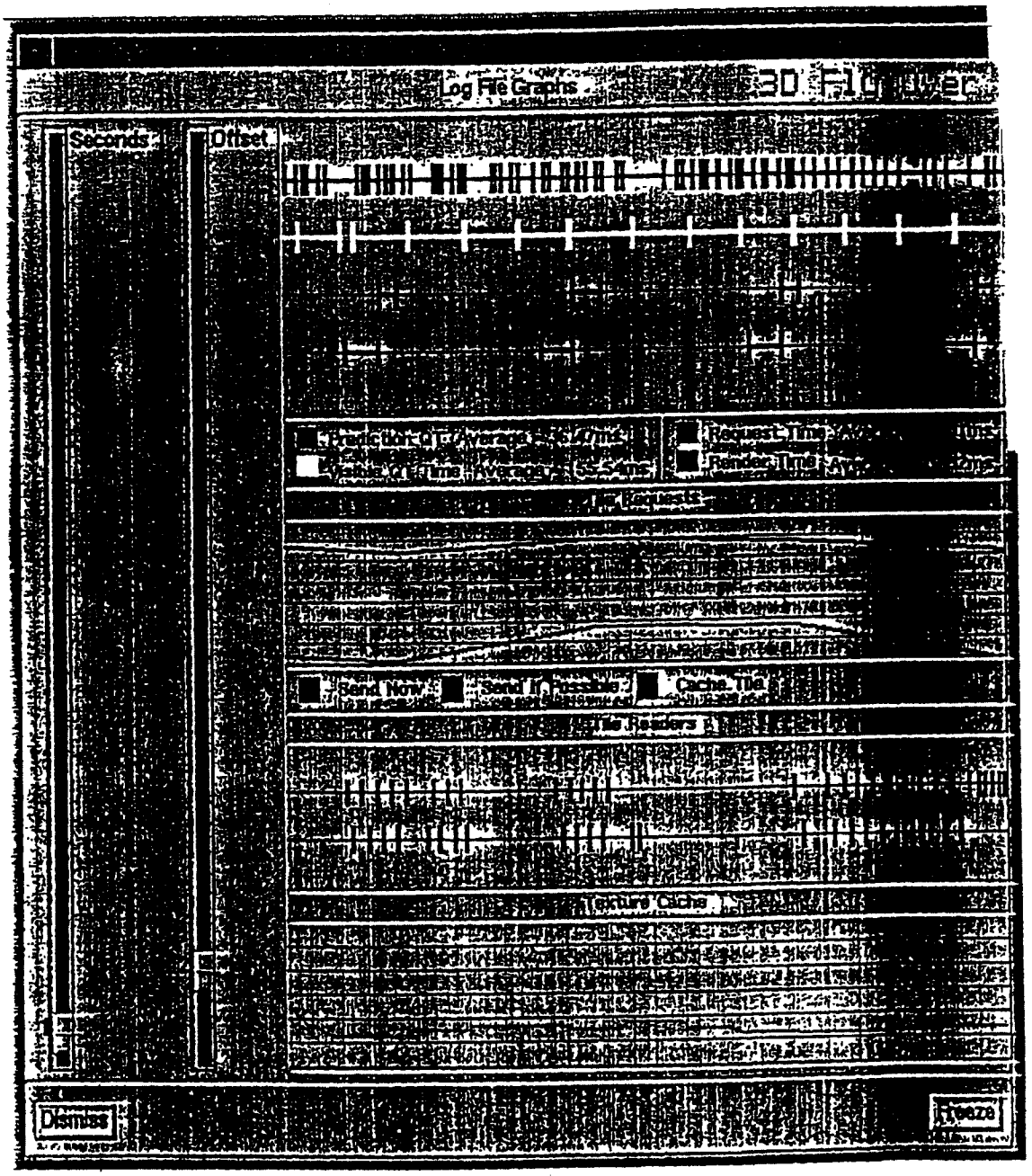
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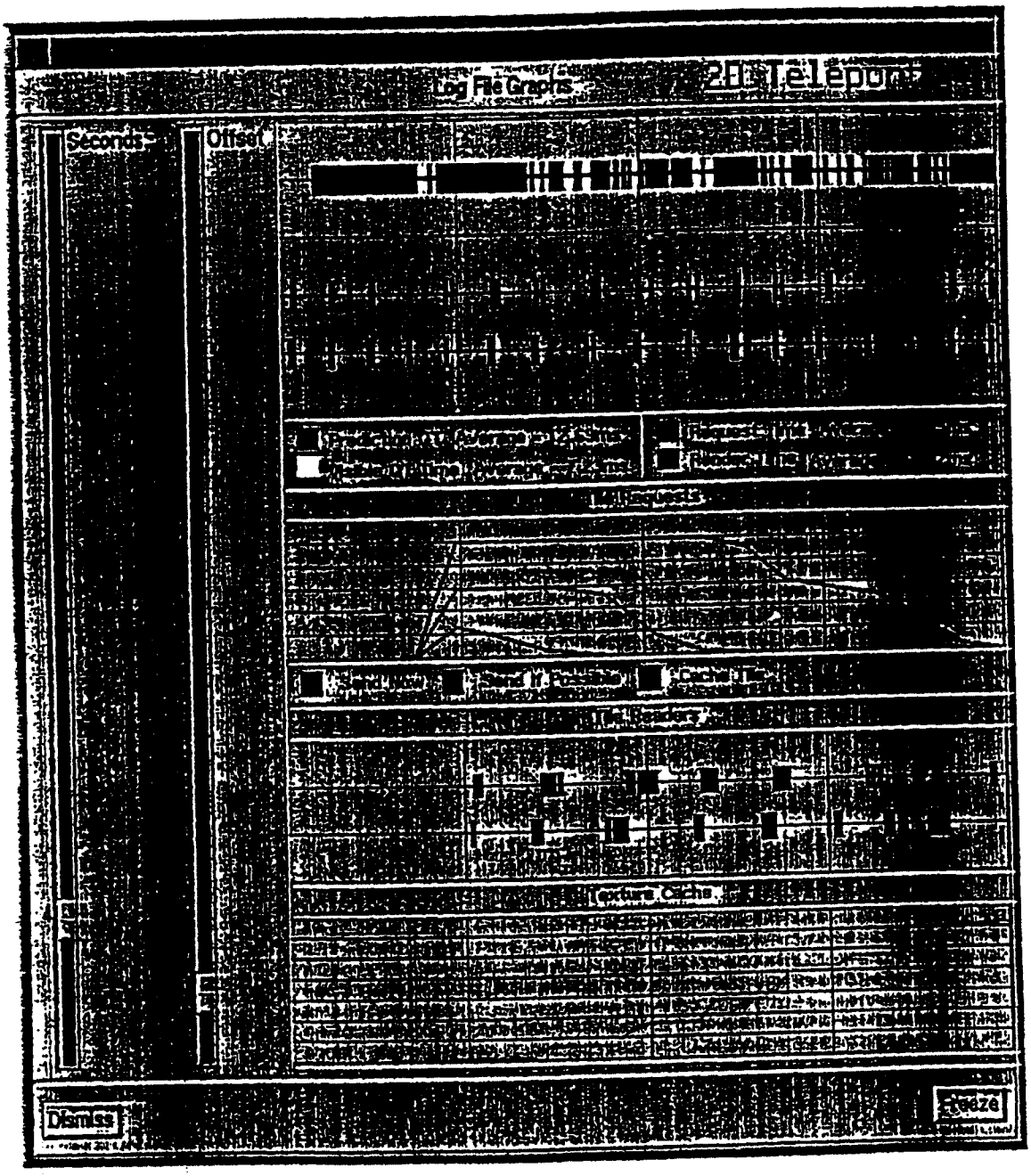
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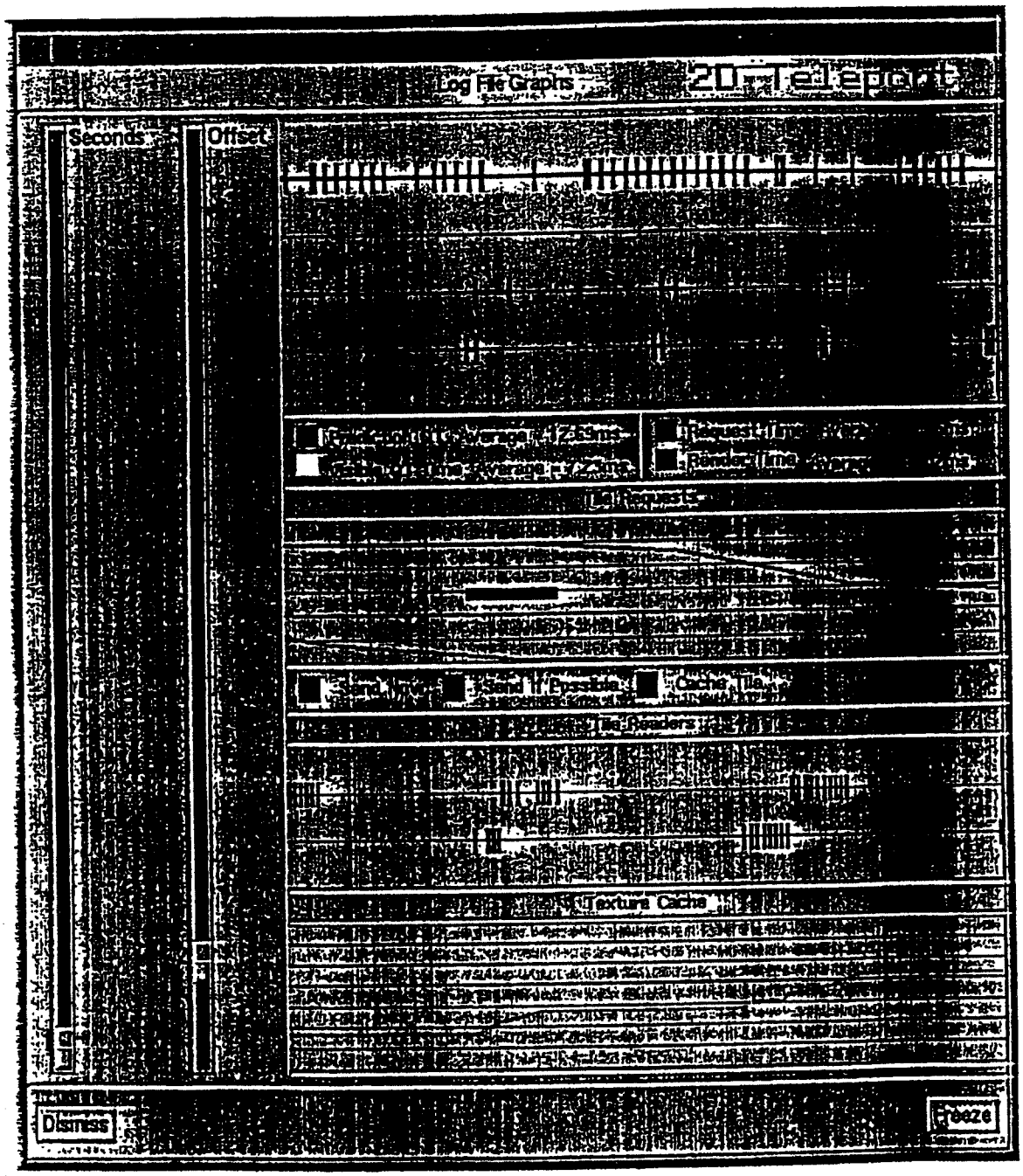
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Advantages of Current Approach

- Quad-tree-based rendering allows scene to be rendered quickly even when data is missing
- Separation of graphics and I/O allows fast response to user's movements even if network response is slow
- Separation of graphics and I/O allows high-speed transmission of data
- TerraVision can run on slower networks, but with reduced image quality
- High-speed networks provide high image quality at all times

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Future Work

- Improve performance and interface
  - optimize graphics performance
  - improve rendering of terrain shape
  - implement more sophisticated prediction algorithms to improve data through-put and hence image quality
  - introduce feedback mechanisms to provide more even graphics rates
  - provide more intuitive mechanism for high-speed fly-overs
- Refine timing graphs and logging capabilities

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Conclusions

- Basic TerraVision architecture is correct
- Remaining performance bottlenecks are primarily hardware related
- High-quality interactive visualization of large, distributed, terrain data sets is made possible by high-speed networks

http://www.ai.sri.com/~magic/

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